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Mobile RHS: a mobile application to support the "River Habitat Survey" methodology

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Abstract

The Fluvial Ecology Laboratory at the University of Trás-os-Montes and Alto Douro (LEF-CITAB) uses the River Habitat Survey (RHS) methodology a Water Framework Directive accepted method for assessing the character and habitat quality of rivers, which involves the use of a paper questionnaire, GPS and photographic camera for the collection of data in the field, which can be very cumbersome. In order to make this a more efficient and rapid process LEF-CITAB suggested the creation of a mobile application to record field data. This paper outlines the development of the proposed mobile application – Mobile RHS.

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Keywords: River Habitat Survey; Paperless Forms; Mobile Cloud Architecture; Android.

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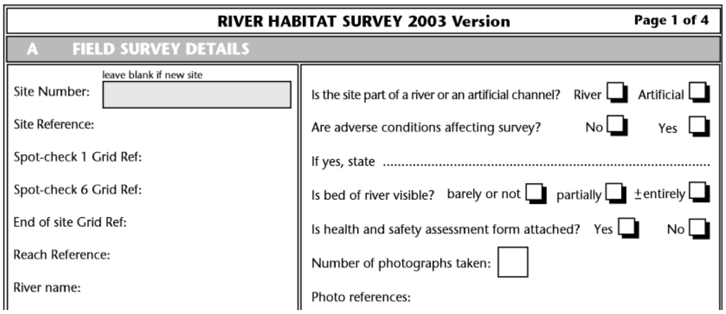
1. Introduction

River Habitat Survey (RHS) is one of the most widely used methodologies for assessing the physical quality and diversity of river habitats in Europe, including Portugal [1, 2]. RHS data is collected in the field using paper forms (see Fig. 1), which is very difficult in rainy conditions as the paper becomes damp and fragile. RHS also requires that a GPS and camera be carried into the field, which together with the field sheet and RHS manual, can be cumbersome.


RIVER HABITAT SURVEY 2003 Version Page 1 of 4

A FIELD SURVEY DETAILS

leave blank if new site
Site Number:
Site Reference:
Spot-check 1 Grid Ref:
Spot-check 6 Grid Ref:
End of site Grid Ref:
Reach Reference:
River name:

Is the site part of a river or an artificial channel? River Artificial
Are adverse conditions affecting survey? No Yes
If yes, state ....
Is bed of river visible? barely or not partially ±entirely
Is health and safety assessment form attached? Yes No
Number of photographs taken:
Photo references:

Fig. 1. River Habitat Survey questionnaire. Source: http://www.riverhabitatsurvey.org.

Today's mobile devices, particularly smartphones, feature very interesting characteristics to implement custom mobile solutions. For example, they allow voice and data communication anywhere, they are highly portable (have reduced dimensions and weight and great energy autonomy), have an impressive capacity for data processing and storage and house integrated high resolution cameras and GPS. The large, high resolutions screens have good contrast and finger touch interface. These devices are sold at affordable prices and accessible to almost every member of society [3].

With these characteristics in mind the Fluvial Ecology Laboratory at the University of Trás-os-Montes and Alto Douro (LEF-CITAB) proposed the development of an application that would allow the completion of the RHS 4 page field sheet using smartphones in the field for more effective assessment of river habitat quality. This paper presents the “Mobile RHS”, an application developed and implemented for the android mobile operating system.

The paper includes an outline of the RHS methodology, the development process of the application “Mobile RHS”; the developed application “Mobile RHS”; and final remarks regarding the development and use of the application.

2. River Habitat Survey methodology

Rivers are a vital part of the landscape, providing a plethora of ecosystem services ranging from biodiversity, water supply and regulation, fertile soils, flood and erosion control, dilution of wastewaters, energy and recreation [4]. It is important that water managers and researchers use reliable methodologies and protocols to produce data to assess river system health and take measures where appropriate. This is especially relevant for the Water Framework Directive (WFD) where compulsory Programmes of Measures must be implemented where rivers fail to meet “Good” ecological quality in River Bain Management Plans. The physical character of river systems, such as substrate and flow types, bank profiles and proximate land use, provide the abiotic template upon which habitats are formed, shaping the structure and function of communities that inhabit them and exploit their resources [5].

Originally developed in the United Kingdom, River Habitat Survey (RHS) is one of the most widely used methodologies for assessing the physical quality and diversity of river habitats in Europe, including Portugal [1, 2]. RHS is versatile and detailed field based method used to “characterise and assess, in broad simple terms, the physical character of freshwater streams and rivers” [1]. RHS can and has been used for many types of study ranging from conservation and river restoration issues to WFD compliant monitoring of water bodies [6-10]. RHS is routinely used by LEF-CITAB for assessing river habitat quality across Portugal from Water Framework Directive monitoring programmes to assessment of river restoration measures.

The RHS methodology gathers physical habitat data over a 500m reach based on fixed surveyor choices (i.e. the user must use standard categories given by RHS methodology). Data on riverbank features, flow and substrate types, proximal land use and the presence of macrophytes are gathered at 10 spot checks spaced at 50 metre intervals, followed by a “sweep up” of habitat features and land use carried out over the entire 500m reach. A count is also made of riffles, pools and point bars; these are important mesohabitats associated with patterns of fluvial erosion and deposition. Data gathered using RHS is used to calculate two indices: the Habitat Quality Index (HQA) is a score of habitat quality and diversity of features such as substrate and flow types, as well as other in channel features such as deposition bars. The higher the HQA, the more diverse the river habitat and the potential for supporting biodiversity The Habitat Modification Score provides an estimate of the degree of modification (e.g. resectioning and reinforcement of the banks or river itself) and presence of artificial features (e.g. bridges and weirs).

Although RHS is widely used, there are some difficulties concerning its application in the field and subsequent calculation of the HQA and HMS in the office. The four page printed RHS field protocol takes approximately an hour minimum to complete in the field (Fig. 2).

Fig. 2. River Habitat Survey methodology requires a 4 page form to be completed in the field.

Completion of the field protocol, even with a weatherproof clipboard, is very difficult in rainy conditions as the paper becomes damp and fragile. This can lead to delays in the gathering of important environmental information. RHS also requires that a GPS and camera be used into the field, which together with the field sheet and RHS manual, can be cumbersome, especially since RHS is usually carried out together with other types of sampling (e.g. macroinvertebrates and fish) programmes. In the office, RHS data recorded on the field sheets has to be manually introduced into the freely downloadable Rapid 2.1 software developed by the Centre for Ecology and Hydrology, UK [11]. Developed using Microsoft Access for Window 2003, Rapid 2.1 can be used to store RHS data and calculate HMS and HQA indexes. However, Rapid 2.1 only works with earlier versions of Access and is not suitable for use in Access 2007 or later versions of this software.

3. Mobile RHS development

The methodology used for development of the Mobile RHS was the Rapid Application Development (RAD) model proposed by James Martin in 1991 [12]. RAD is an iterative software development process model based on the construction of successive prototypes (incremental prototyping) within short development time periods (time boxing technique) [13].

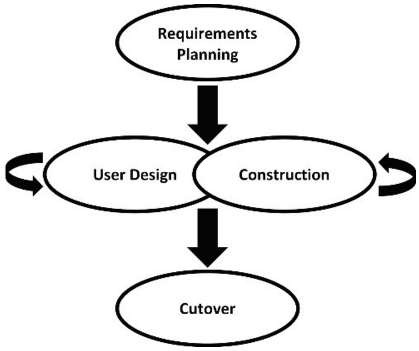


Fig. 3. RAD model.

The RAD approach as proposed by James Martin encompasses the following phases [12, 14] (see Fig. 3):

- Requirements planning: an initial phase where stakeholders, including the IT staff, discuss and agree on business needs, project scope, constraints, and system requirements.
- User design: users interact with systems analysts and develop all the models and prototypes that represent all systems processes, outputs, and inputs. This is a continuous and interactive process that allows users to understand, modify, and eventually approve a working model of the systems that meets their needs.
- Construction: system development, in this particular case, the Mobile RHS.
- Cutover: data conversion, testing, changeover to new system, and user training.

The Unified Modelling Language (UML) was used to establish requirements specifications, in the requirements planning phase. UML is one the most popular languages used by software developers to specify, visualise, construct and document all of the artefacts comprising a software system [15, 16]. The following sections outline the work carried out in each of the four phases of RAD methodology.

3.1. Requirements planning

In this phase the project different stakeholders evaluated and decided on the best option for application development to support the RHS methodology. Criteria taken into account included: (1) the study of RHS methodology, in particular recording data in the field; (2) a survey of LEF-CITAB team field experience, needs and expectations concerning the RHS application and (3) analysis of the Rapid 2.1 program.

Based on this analysis and the needs of the RHS methodology in particular, the use of GPS and photographic camera, a decision was made to develop an application for mobile devices.

3.2. User design

Several models were developed in this phase such as the use case diagram, class diagram and the architecture diagram presented in the following sections.

3.2.1. Use case diagram

A total of three actors interact with the system (Fig. 4). The “Admin” actor has access to the same features as the “User” actor; however, the “Admin” actor can add users to the application. The “User” actor (also referred as the surveyor because this actor fills in the survey field protocol) creates and fills in the form (survey) and lists the existing surveys in the database. In order to complete the form, the user should be able: to navigate easily between its pages and within each one of the different sections that make up the field protocol; to add counts of mesohabitat features (riffles, pools and point bars) and also take photos and record GPS coordinates. For the surveys list, the “User” actor must be able to consult the list of surveys and the detailed information of each individual survey together with an interactive photo presentation including a map of the recorded RHS spot checks. The actor must also be able to calculate the HMS and HQA indices, pull up more detailed data and even edit the completed survey. By presenting the surveys in this list, the actor can check survey status (i.e. complete / incomplete), delete it and submit it online. Finally the "Time" actor is responsible for registering the GPS coordinates from time to time in order save the travelled route.

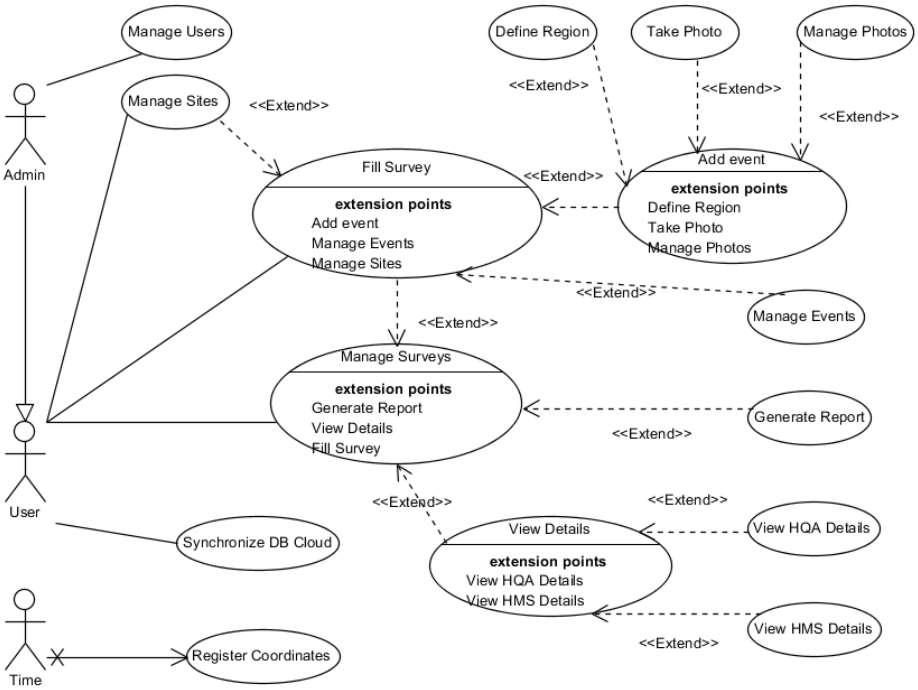


Fig. 4. Use-Case Diagram.

3.2.2. Class diagram

A simplified version of the class diagram (Fig 5) which will be used to implement the structure of the application based on identified requirements, shows the class "Survey", which represents the RHS questionnaire, in the centre of the scheme and its links with the remaining classes. The Survey class comprises numerous attributes: in order to ensure clarity they are not all represented in the figure.

A survey must be performed (filled in) by a user (also known as surveyor) and a user can fill in several surveys (1 to many relationship between the class User and Survey). The Admin class is a particular type of user that can perform user management operations beyond the established user operations.

As previously explained, a survey must be performed on a river site in the field (location), thus a survey is always related to a particular site and one site may be subject to various surveys (1 to many relationship between Site and Survey classes). During the survey process, situations may arise where it is necessary to record particular features (e.g. the presence of major weirs). These events may or may not have one or more photos associated with them, however they but always have GPS coordinates.

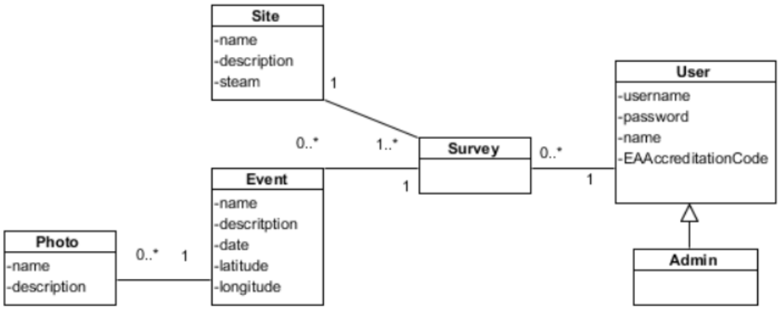


Fig. 5. Class diagram.

3.2.3. System architecture

System architecture proposed for Mobile RHS application comprises two parts: the client application in the smartphone and the server in the cloud. The client application communicates with the server in the cloud to store and synchronise data. This system architecture is known as Mobile Cloud Architecture [17].

3.3. Construction

An Android operating system was used to develop the mobile application for this platform as a result of the existing expert knowledge of the working group. The application was developed using the Android Studio and the Java programming language. The “parse.com” platform was chosen to store data on the server.

Mobile RHS application construction comprised several phases, namely: construction of the database, data structure support, and simplified methods to access information; design of the user interfaces for defining and creating the organization and sequence of activities; implementation of the relations between fields of the database and user interfaces form elements; creation of an automatic method for storing information; presentation of information in the different formats upon its relevance and format; form edition; and finally, communication of data to an external entity.

Currently, work is being carried out on the implementation phase of user interfaces which are almost all nearing completion. The organization and sequence of activities has been implemented for interfaces relating to pages and sub-field form.

3.4. Cutover

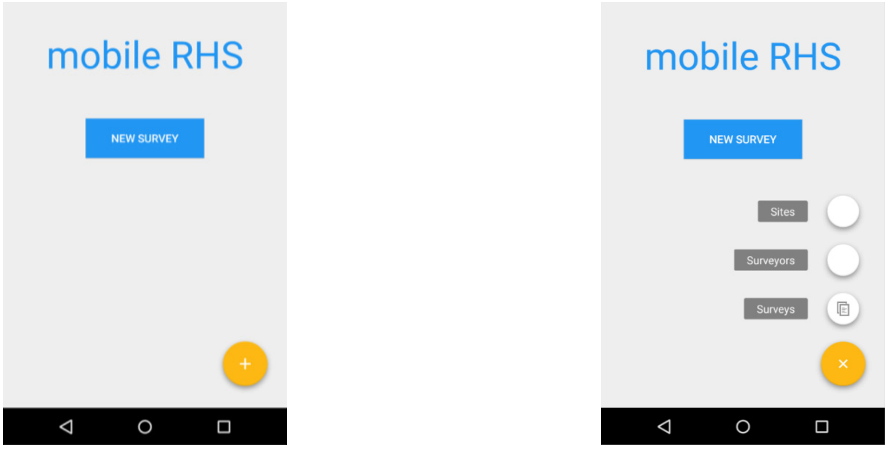
This phase will be carried out by conducting field tests of Mobile RHS application with experienced LEF-CITAB team members.

4. Mobile RHS application presentation

The best way to present the Mobile RHS application is to show how it works from beginning to end. When the Mobile RHS application is started, a login screen pops up to the user to fill in their RHS credentials. If the credentials are valid Mobile RHS application starts and a screen appears (Fig. 6a)) that provides the user with the option to create a new survey or to click the button in bottom right to view other options (Fig. 6b)): (1) to create a new site; (2) that allow the Admin user to create new users (surveyors); and (3) to browse existing surveys.

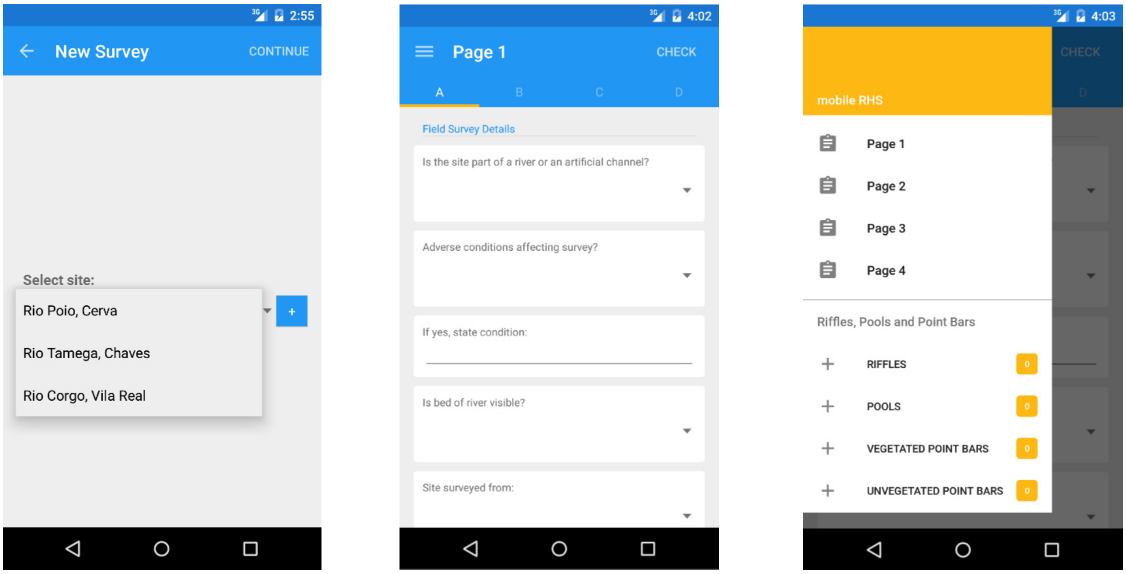
A user that chooses to create (start) a new survey must first select the site where the survey is going to be performed (Fig 6a)). If the site does not exist the user can add a new one by pressing the orange plus sign (“+”), which is selected by default.

Once the new survey has been created, the user can start to complete the form (Fig. 7b)). The survey, comprising four pages that are divided into sections (A, B, C, etc.), shows page 1 with section “A” selected. Navigation between different sections of RHS protocol is done by clicking the respective letters (below the page number) or through swiping. A side menu can also be used to change between pages (Fig. 7c)).



a) b)

Fig. 6. Main view.



a) b) c)

Fig. 7. Survey pages.

Events can be added while filling out the survey. Each event corresponds to an event or feature along the 500m survey route that the user (surveyor) considers relevant for recording. The user can take and add a photo or write a description and record the GPS position where the event or feature occurred. The moment the event is added, the GPS position and time (timestamp) are stored.

The “check” option, situated in the upper right hand corner of the page, can be selected at any time while completing the RHS form (Fig. 7b)). Once selected, the check option displays a message to the user that informs them whether the survey is completed or not (i.e. if all of the sections have been completed). If the survey is not completed, the Mobile RHS application indicates to the user the information that is missing.

Fig. 7c) presents the side menu of the Mobile RHS application that is displayed when filling out the survey. This menu allows the user to navigate between the different sections of the form (Page 1, Page 2, Page 3 and Page 4), and add counts of mesohabitats (riffles, pools and point bars). These values can also be changed on section C of Page 1.

5. Conclusion

The Mobile RHS application allows the River Habitat Survey (RHS) method to be completed from a smartphone. This was achieved by converting the four page field protocol, containing 18 sections (from A to R; Fig. 1) into an electronic format (see Fig. 7 b).

The application uses a simple data entry method, and can create events at any time. It can also take photographs and records the GPS position of spot checks and important river habitat features. The Mobile RHS application allows synchronization of cloud data, avoiding the use of outdated application Rapid 2.1. This also reduces human error resulting from the manual introduction of field data. There is data security assurance in order to meet basic safety principles: information can only be accessed by authorized personnel, information must be returned in the same manner in which it was stored and users must identify themselves (through user credentials). The application has a friendly, intuitive and easy to use interface, guaranteeing effective interaction between the user and the system.

Although it has not been thoroughly tested, the application meets the conditions for the conservation of river habitats evaluation visits and solves many of the difficulties identified by the LEF-CITAB group and from the Rapid 2.1 software analysis. As a result, data collection for the RHS methodology is now a more simple and efficient process.

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